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A roadmap for selecting host countries of wind energy projects in the framework of the clean development mechanism

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Abstract

This paper presents a stepwise evaluation procedure for assessing the attractiveness of different developing countries to host projects on clean technologies in the framework of the clean development mechanism (CDM) of the Kyoto Protocol (KP). The present analysis focuses on wind energy projects and examines a set of developing countries in Eastern Europe, Middle East and Northern Africa. The proposed approach proceeds to the gradual exclusion of candidate countries that do not satisfy fundamental technical and economic conditions influencing the profitability of the project. In the last stage, the countries presenting the highest return are evaluated with respect to a wider set of criteria denoting the ease of making business in each country. The outcome of the evaluation procedure is to identify the most appealing investment opportunities deserving a more detailed techno-economic analysis following the guidelines of the CDM. The obtained results are also useful in order to highlight the most critical factors influencing the economic return of wind energy projects under the framework of the flexible mechanisms of the KP.

Keywords: Wind energy; Clean development mechanism; Multicriteria analysis; ELECTRE III; Baseline emission factor; Kyoto Protocol

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Contents

1. Introduction

According to the Kyoto Protocol (KP), the industrialized countries (Annex-I countries) have committed themselves to reduce their emissions of greenhouse gases (GHG) to the amounts agreed under article 3. In order to meet their commitment in the most cost-effective way and taking into consideration that the location of emission reduction is practically non-important, KP provides a co-operative framework giving to Annex-I countries the possibility to reach part of their target through the so-called flexible mechanisms: emissions trading, joint implementation and clean development mechanism (CDM).

In the case of CDM, article 12 of the KP provides that any Annex-I country or any licensee legal entity of Annex-I country is allowed to be credited for emissions reductions achieved by investing in projects located in developing (non-Annex-I) countries, thus profiting from the lower abatement costs in the host country. Moreover, the CDM is intended to support the sustainable development of host countries, since Annex-I countries are expected to contribute with financial resources and technology transfer in the realization of projects that would not have been implemented without the incentive of gaining tradable certified emission reductions (CERs) [1]. CDM projects are thus beneficial for both the investing and the host country but also for the whole planet, since non-Annex-I countries are not subject to binding emission ceilings and their development is still strongly coupled with rapidly increasing emissions.

Among the eligible technological options, electricity from renewable energy sources (RES) could play a predominant role not only because of its great mitigation potential, but also because of the growing electricity demand in developing countries. However, the extent to which CDM can practically foster the deployment of RES in these countries remains still elusive [2–4].

It is obvious that the size of the CDM market in the field of RES exploitation and its geographical and technology distribution is influenced by a multiplicity of factors in both developed and developing countries, including technological choices, evolution of energy

prices and geopolitical factors. The rules of the CDM itself are also of primary importance to give the necessary impetus to the deployment of the market forces [5,6].

The present analysis concentrates on wind power generation which is experiencing impressive growth rates, especially in industrialized countries. The question raised is how to select the most appealing host country for a wind energy project by taking into account the multiplicity of parameters influencing the investment decision. In order to answer this question we developed a screening evaluation procedure for gradually restricting the number of candidate countries and finally uncovering the most promising one(s). The analysis starts with simple logical conditions, moves to a conventional financial analysis and ends with a multicriteria decision analysis (MCDA) aiming to broaden the evaluation perspective beyond purely economic considerations. The developed approach is implemented in a small sample of non-Annex-I countries located in Middle East, Eastern Europe and Northern Africa. Contrary to the big CDM markets of India and China, the reduction potential in most of these countries remains practically unexploited.

In addition to the above objective this paper aims at demonstrating the effect of CDM on the deployment of wind energy in developing countries and investigating the impact of relevant key-parameters on the profitability of wind energy projects.

The remainder of this paper is structured as follows. After this introductory part, the current status of wind energy exploitation under the CDM is examined in Section 2. Section 3 presents the developed methodological approach by giving particular emphasis to the estimation of the baseline emission factor and the multicriteria method applied in the last stage of the evaluation procedure. Section 4 presents the examined case study and discusses the obtained results. The main findings and the conclusions of the study are summarized in the last section.

2. Current status of wind energy exploitation under the CDM

Following the Marrakesh Accords of late 2001, which provided the detailed rules to make the CDM workable and established the CDM Executive Board and other necessary institutions, the number of projects applying for registration under CDM is rapidly increasing. In May 2006, the total number of projects registered or under validation was 744 and covers a wide variety of clean technologies. As shown in Fig. 1, RES represent the 57% of the total number, of which 93 projects (13% of the total number) concern wind power plants [7].

It should be noted that the contribution of these projects to the total generated CERs is completely different because of their dissimilar capacity and—mainly—of the different global warming potential of the respective GHG. Specifically, a few projects reducing HFC's in the industrial sector represent 41% of total GHG emissions reduction, compressing the contribution of the other technologies to much lower levels (Fig. 2). In the particular case of wind energy, a total number of 93 projects being registered or under validation contribute with a total 3636 MW capacity and with 6686 kt CO_2eq annual reduction [7].

Focusing on the geographical distribution of wind energy projects, Fig. 3 shows that up to now relevant investment activities are directed principally towards the vast markets of India, Brazil and China, the three exceeding 63% of the total number of projects [7].

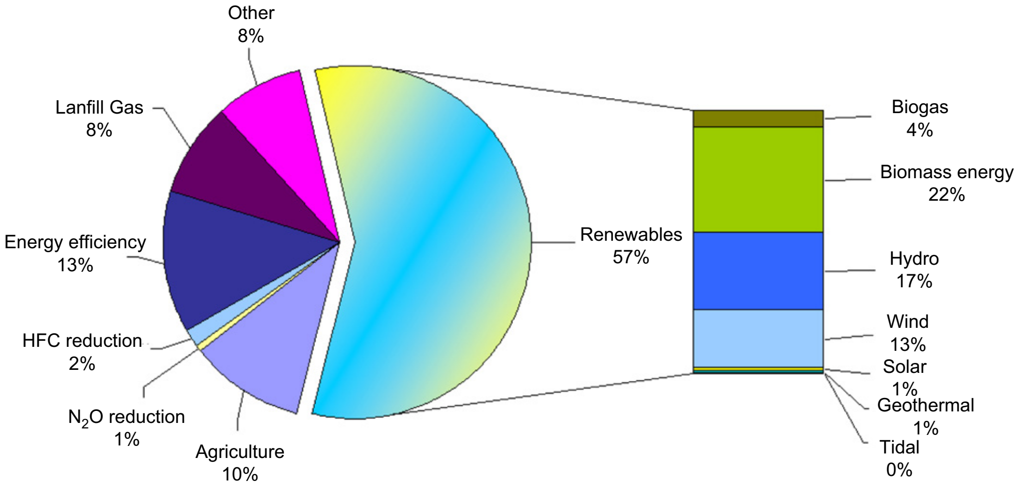

Fig. 1. Distribution of CDM projects registered or under validation.

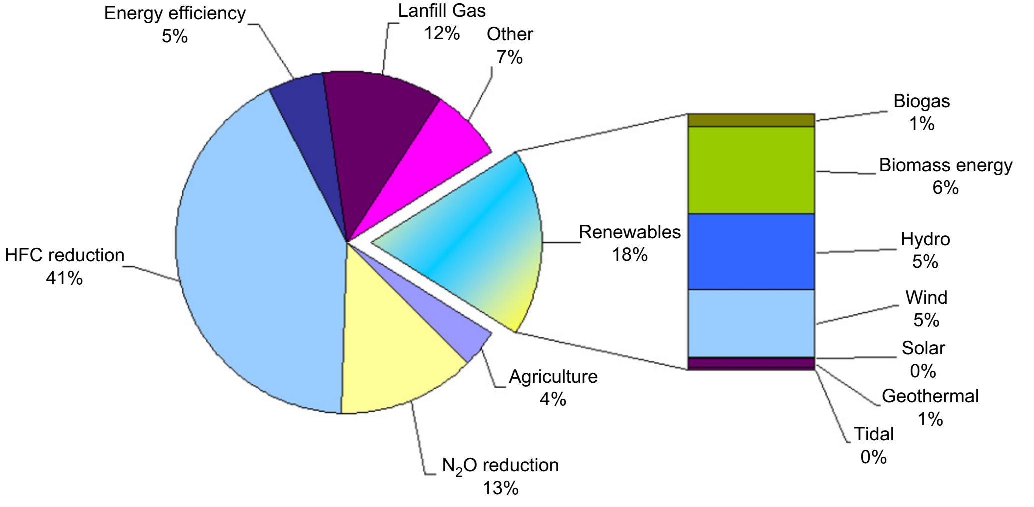

Fig. 2. Contribution of CDM projects registered or under validation to total generated CERs.

3. Methodological approach

3.1. General description

The scope of the present paper is to develop a systematic and consistent evaluation procedure for identifying the most attractive countries—among a given set of non-Annex-I countries—to host wind energy projects in the framework of the CDM flexible mechanism of the KP. The evaluation refers to a typical wind power plant for which technical and economic figures are calculated on the basis of relevant country-specific

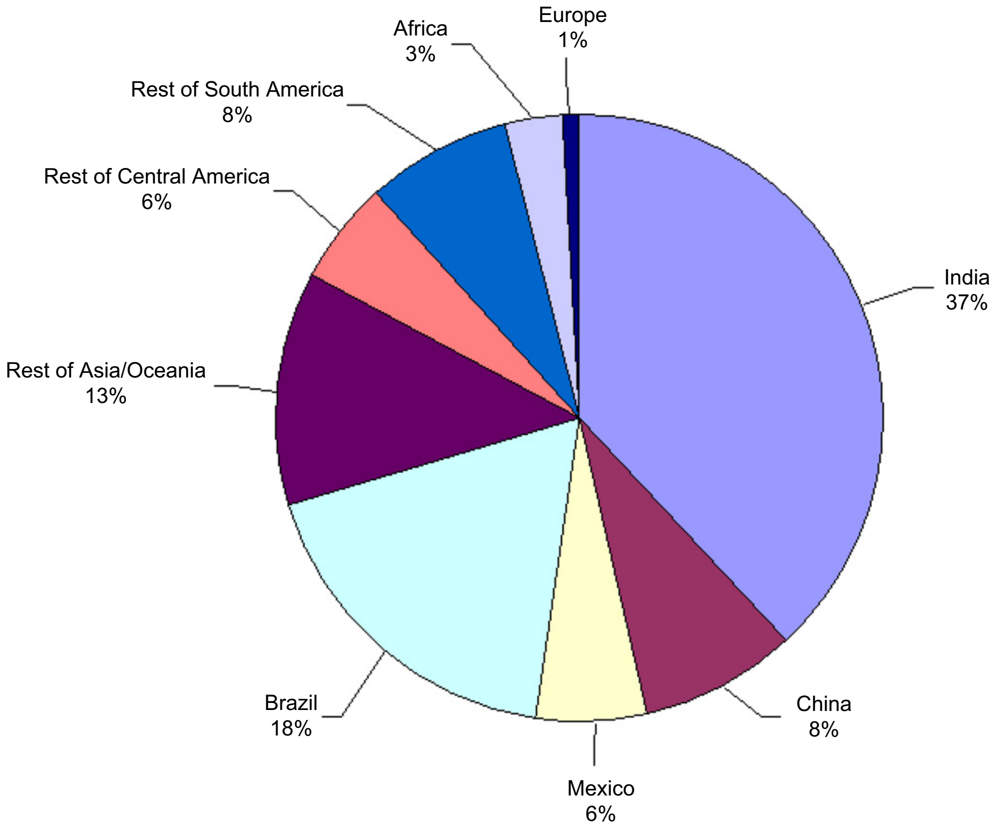

Fig. 3. Geographical distribution of wind energy CDM projects registered or under validation.

parameters. The analysis includes the following steps that are graphically depicted in Fig. 4:

1. *Wind potential condition*: in this preliminary step countries with low wind potential are excluded from the subsequent analysis. The exclusion criterion is the average load factor calculated for the considered type of wind turbines from data on the average wind speed in the most privileged areas of each country. The corresponding limit value is set at 15%.
2. *Preliminary financial analysis*: the internal rate of return (IRR) is used to estimate the profitability of a typical wind energy project in each candidate host country. It is assumed that all technical characteristics, as well as investment and operation and maintenance costs are the same in all examined countries in order to better indicate the influence of country-specific parameters. Thus, in addition to the load factor previously determined, the electricity price is taken into account in each country. The corresponding limit value for IRR is set at the low level of 5% in order to not exclude countries that could show a satisfactory return if the additional revenues from the support provided by CDM are included in the cash flow.
3. *CDM eligibility condition*: this criterion aims at provisionally excluding host countries that at the time of the analysis do not meet the eligibility conditions set by the CDM.

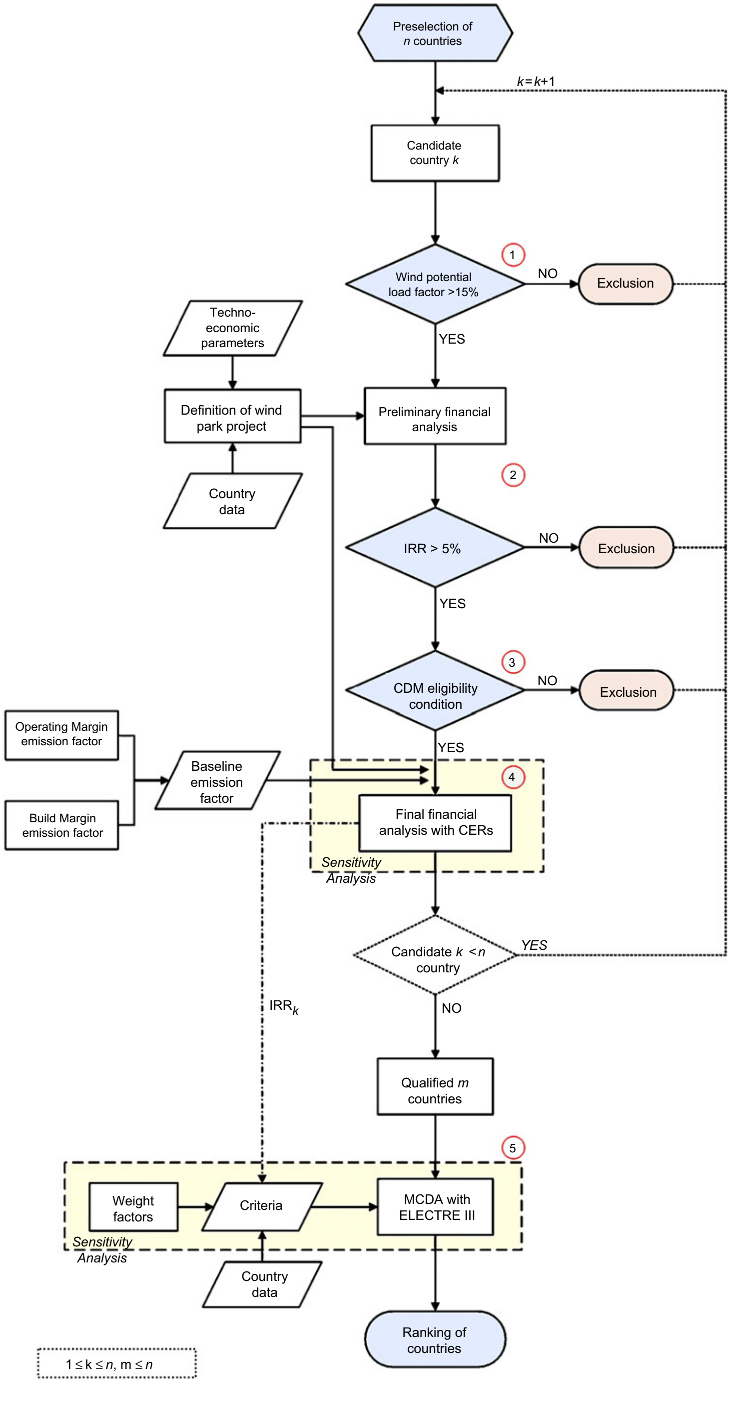

Fig. 4. Logical diagram of the screening and evaluation procedure.

Since this condition can be fulfilled some time in the future, countries excluded in this stage are placed in a separate list of potentially candidate host countries.
4. *Final financial analysis*: for eligible countries the preliminary financial analysis is extended as to include the additional revenues from the generated CERs. To this purpose, a baseline emission factor of the country is used for determining the GHG emission reduction expected to be achieved through project implementation. This factor is calculated according to the decisions of the CDM Executive Board [8] by taking into account not only the current electricity mix, but also its future changes as explained in Section 3.2.
5. *MCDA*: in this final step the set of developing countries that successfully passed all previous tests, are comparatively evaluated with respect to a wider set of criteria besides the already calculated IRR. The rest of evaluation criteria refer to political, administrative and legal conditions contributing to the ease of making business in the country and highly influencing the final investment decision.

As shown in Fig. 4, a sensitivity analysis is performed in the final financial analysis (step 4) and in the MCDA (step 5). In the former case, the aim is to identify the parameters having the greatest influence on the project's profitability and to determine the range of expected IRR in each country. In the case of MCDA, the sensitivity analysis focuses on the robustness of the resulting ranking of countries by varying the relative weights of importance attributed to the evaluation criteria.

The above logical procedure can be applied to any set of non-Annex-I countries and any renewable energy or clean technology with the purpose of singling out—in each case—the most appealing investment opportunities. Moreover, in each project type, the most critical parameters have to be identified in order to draw the necessary attention of potential investors on the effect of their likely fluctuations.

3.2. Baseline emission factor

An essential requirement in applying the two project-based mechanisms of the KP, the joint implementation and the CDM, is to estimate the development of the GHG emissions in the absence of the project. To this purpose, a hypothetical non-project scenario, referred to as the project's baseline, should be constructed in each country by taking into account the existing system's structure and the expected capacity additions. The amount of CERs that will be credited to the examined wind energy project, results from the achieved reduction in GHG emissions, relative to this baseline scenario, which is calculated on the basis of the so-called baseline emission factor.

The baseline emission factor is estimated according to the technology mix assumed in the baseline scenario, by following the decisions of the CDM Executive Board regarding the approved consolidated baseline methodology ACM0002, and using the default IPCC values and the IPCC Good Practice Guidance. More specifically, the baseline emission factor is calculated as the 'combined margin', which is the weighted average of the 'operating margin' (OM) and 'build margin' (BM) factors. In particular, for wind power projects the default weights for OM and BM are, respectively 0.75 and 0.25 [8].

The 'OM' emission factor represents the average emission factor of the existing electricity system and is calculated by using one of the following methods:

- Simple OM
- Simple adjusted OM

- Dispatch data analysis OM
- Average OM

The preferred methodological option recommended by the consolidated methodology ACM0002 is the dispatch data analysis [8]. However, this method is used only rarely in project design documents registered in the UNFCCC because it requires detailed information about the operation of the considered electricity system. Therefore, the OM calculated in this study is based either on the simple or on the average OM method. The former excludes the 'low cost/must run' power plants from the calculations of the OM emission factor and can only be used if their contribution is less than 50% of total electricity generation. If the share of 'low cost/must run' units exceeds 50%, then the average OM approach is followed.

Nevertheless, the most complicated stage in computing the baseline emission factor is to estimate the BM emission factor, which reflects recent capacity additions to electricity system and relevant trends. It is calculated as the generation-weighted average emission factor of the greater in total annual generation, of either the 5 most modern power plants or the most recent built units contributing by 20% to the grid system. Since data regarding the installation year of power units are difficult to find, especially for the countries under consideration, the BM emission factor is calculated on the basis of the envisaged investment decisions in the near future by taking into account changes in the electricity mix that have occurred or are expected to occur in the period 2003–2010, according to official plans published by national or international bodies.

3.3. The multicriteria method ELECTRE III

A multiplicity of MCDA methods is currently available for use in a wide variety of decision situations. In this study, the ELECTRE III method was selected because of its capacity to approximate the way human mind expresses and synthesizes preferences in front of multiple contradictory decision perspectives. The family of ELECTRE methods is developed by B. Roy and his collaborators at the University of Paris Dauphine, the earliest of which was published in 1968.

All ELECTRE methods belong to the outranking multicriteria approaches which proceed to a pair wise comparison of the examined alternative options in each separate criterion, i. The underlying concept is to measure for each pair of alternatives a and b in each criterion, the strength of support for the hypothesis that '*a is at least as good as b*'. This information is provided through the so-called concordance indices $C_i(a, b)$ taking values within the interval [0–1], such that higher values indicate stronger evidence in support of the above hypothesis. The comparison of alternatives is made on the initial measurement scale, either quantitative or qualitative, while in the particular case of ELECTRE III, it is recognized that human preferences do not pass abruptly from the state of indifference to strict preference. Thus, indifference and/or preference thresholds can be defined by the decision maker in each criterion, against which the difference in the scores of each pair of alternatives is compared. The overall concordance index $C(a, b)$ is then calculated as the weighted average of partial indices over the whole set of criteria.

Besides, a discordance index $D_i(a, b)$ can be constructed in each criterion i to measure within the interval [0–1] the strength of support against the hypothesis that '*a is at least as*

good as b'. Here, the comparison takes into account a veto threshold denoting that if the difference in the scores of the two actions is greater than a certain amount, then the hypothesis cannot be supported for the worst performing action. Thus, a credibility index $S(a, b)$ is calculated as the concordance index $C(a, b)$ lessened by a certain amount according to the value of discordance indices, if any. If no veto threshold is specified, then we define $D_i(a,b) = 0$ for all pairs of alternatives, while $S(a,b) = C(a,b)$.

The values of the credibility indices $S(a, b)$ are used to construct outranking relations within the whole set of the examined alternatives that can be further exploited to determine the best alternative or to rank them from the best to the worst one. It should be noted that it is possible that some of the options remain incomparable, meaning that there are not enough arguments to support the hypothesis that either a or b is at least as good as the other.

Interested readers can find more details on multicriteria outranking methods and especially on the ELECTRE III method in [9–11].

4. Case study

The present study refers to a typical wind power plant of 51 MW, comprising 60 commercial turbines of 850 kW (60 m hub height and 52 m of rotor diameter). The investment cost is assumed to amount at 1000 €/kW, while annual operational and maintenance cost are set equal to 1.5% of the investment cost [12]. Although cost figures are expected to vary with the exact location of the site, they are assumed to be the same in all cases in order to better isolate the effect of the less controllable country-specific parameters on the project's profitability.

Fifteen non-Annex-I countries have been included in the analysis. These are the following:

- Armenia, Georgia, Moldova in North-Eastern Europe,
- Albania, Bosnia and Herzegovina, F.Y.R. of Macedonia, Serbia and Montenegro in Balkans,
- Jordan, Lebanon, Syria in Middle-East, and
- Algeria, Egypt, Libya, Tunisia and Morocco in Northern Africa.

The steps of the evaluation procedure described in Section 3.1 have been implemented and the obtained results are presented in the following paragraphs.

4.1. Wind potential condition

Data on average wind speed in the most privileged areas of the country are collected from international and national databases and experts' reports [13–26]. These data are elaborated through the RETScreen software [27] in order to calculate for the specific type of wind turbines the average load factors shown in Table 1.

It can be seen that 3 countries (Moldova, F.Y.R.O.M. and Lebanon) are excluded from the analysis, since the calculated load factor is below the limit value of 15%, indicating that they are less favored with respect to their wind energy resources.

Table 1
Average load factors in the examined non-Annex-I countries

Country	Load factor (%)
Albania	24 [14]
Bosnia	23 [24]
F.Y.R.O.M.	10 [17]
Serbia	20 [22]
Armenia	16 [15]
Georgia	25 [19]
Moldova	13 [16]
Jordan	33 [18]
Lebanon	12 [18]
Syria	34 [23]
Algeria	23 [21]
Egypt	42 [13]
Libya	33 [26]
Morocco	41 [25]
Tunisia	39 [20]

Table 2
Average electricity tariffs in the pre-selected non-Annex-I countries

Country	Electricity price (€/MWh)
Albania	63.3 [29]
Bosnia	49.5 [28]
Serbia	29.2 [31]
Armenia	68.1 [15]
Georgia	39.8 [32]
Jordan	52.1 [33]
Syria	20.8 [34]
Algeria	27.4 [30]
Egypt	22.5 [35]
Libya	21.8 [36]
Morocco	77.4 [30]
Tunisia	60.6 [30]

4.2. Preliminary financial analysis

The analysis at this stage is performed outside the framework of CDM. Thus, for estimating the profitability of the specified wind energy project, besides the predefined costs, the electricity production (calculated on the basis of the load factors) and the electricity tariff in the country are taken into account. The lifetime of the wind power plant is assumed to be 20 years long, with no remaining salvage value. Regarding electricity tariffs, only two countries have established feed-in tariffs for RES, which are slightly higher (Armenia) or lower (Bosnia and Herzegovina) compared to the mean electricity price [15,28]. For the rest of the countries, tariffs are assumed to be equal to the mean electricity price in the country [29–36]. Table 2 presents the assumed average prices in each of the pre-selected countries.

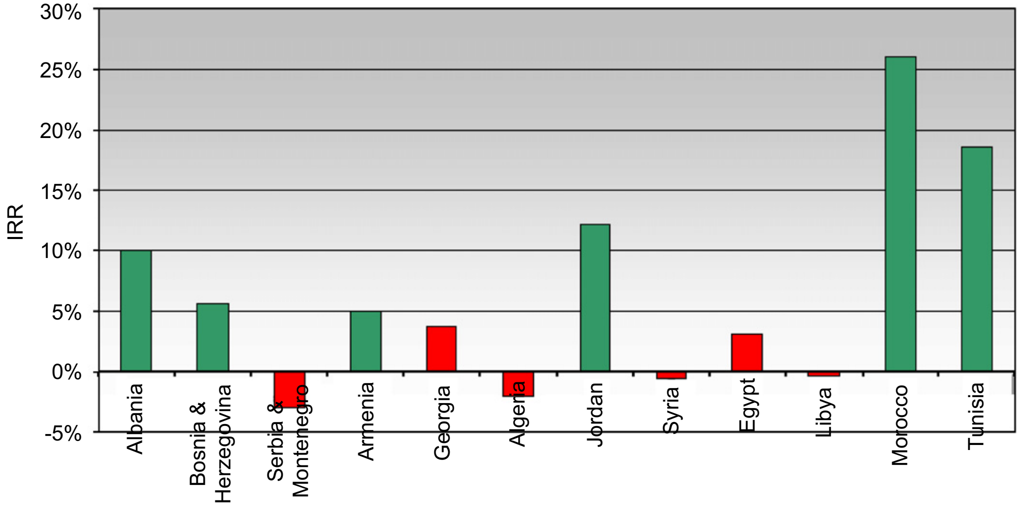

Fig. 5. IRR of a typical wind energy project in the pre-selected countries.

It can be seen that electricity prices vary in a wide range of values, depending on the overall level of the corresponding economies, the composition of the electricity mix and the availability of local energy resources. However, it is the combination of tariffs with load factors in each country determining the IRR of the wind energy project that are graphically shown in Fig. 5. Hence, economic return is found to be higher in Morocco presenting the highest values in both electricity price and load factor. Egypt endowed also with a high wind potential presents a marginal profitability because of its low electricity tariff.

Six additional countries are excluded from the set of candidate options as their IRR is below the limit value of 5%, with four of them presenting negative rates.

4.3. Eligibility condition

Among the 6 countries that successfully passed the preliminary financial test, Bosnia and Herzegovina has been also eliminated from the final set of candidate host countries because until now (June 2006) it has not fulfilled the basic preconditions of the KP: ratifying (no just signing) the KP and therefore designating a national authority for CDM.

However, if this condition is fulfilled in the future, the country can be included in the final stages of the evaluation procedure.

4.4. Final financial analysis

From the initial 15 countries only five are left in the final list including eligible countries with IRR higher than 5%. The question raised in this step is how much the CDM is expected to boost this IRR in order to attract the interest of potential investors. To this purpose, for each of these 5 countries the baseline emission factors defined in Section 3.2 are determined from relevant bibliographical sources [13,37–42] by making the necessary calculations. Specifically for the baseline emission factors of Albania and Armenia, the

Table 3
Baseline emission factors of the qualified non-Annex-I countries

Country	Combined margin (t CO_2/MWh)
Albania	0.103 [13,37]
Armenia	0.108 [13,37]
Jordan	0.609 [37–40]
Morocco	0.738 [42]
Tunisia	0.535 [37,41]

OM emission factor is computed by using the average OM method while in the other three cases, the simple OM method is used.

Table 3 summarizes the so estimated baseline emission factors.

It is clear that the higher the baseline emission factor the more are the emission reduction units (CERs) that will be credited to the project. Albania and Armenia have extremely low emission factors because of their high share of hydropower and nuclear energy, respectively, in their electricity system. Thus they appear from the beginning that they do not represent an appealing option for clean energy projects in power generation sector.

The average price of CERs in the market is assumed to be equal to 15 €/t CO_2eq. It should also be noted that according to the Marrakesh Accords, the CERs generated are subject to a levy—known as the 'share of the proceeds'—equal to 2% of total emission reductions, which will be deposited into an Adaptation Fund in order to assist developing countries to adapt to the adverse effects of climate change.

Fig. 6 gives a comparative view of the IRR of the wind energy projects with and without the support of CDM. The average increase in the IRR in the three more promising countries is approximately 3–4%, with Albania and Armenia showing a negligible difference because of the small amount of generated CERs.

The performed analysis is based on the average values of the influencing parameters, which are expected to vary with the exact location in the country as well as with time, market changes and technical progress. It is therefore particularly important to investigate the influence of each single parameter on the obtained profitability rates. Table 4 shows the extreme changes in the average values (an optimistic and a pessimistic extreme) that are taken into consideration in the sensitivity analysis.

Figs. 7–9 present the results of the performed sensitivity analysis in Armenia, Jordan and Morocco, depicting a low, medium and high rate of return, respectively, by indicating the impact of changes in each single parameter on the project profitability, in comparison to the corresponding basic case scenario.

It can be seen that the impact of the examined changes follows the same pattern independently of the countries' characteristics and of the initial IRR value. In all cases, the load factor, the electricity tariff and the investment cost appear as the most critical factors for the effectiveness of the wind energy project. More specifically, with a 20% decrease in investment cost IRR increases—in absolute values—by up to 8%. Slightly lower increases are estimated for the other two factors. It is clear that the pessimistic values of the examined parameters indicate the opposite effect.

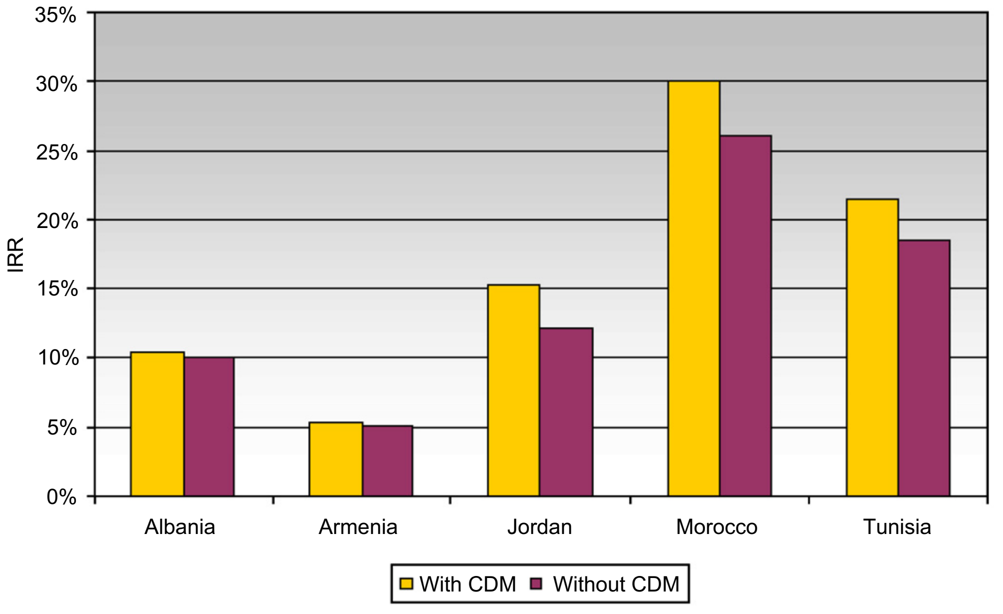

Fig. 6. IRR of a typical wind energy project in the selected countries with and without the support of CDM.

Table 4
Range of values in the sensitivity analysis

Parameter	Pessimistic	Optimistic
Load factor	−20%	+20%
Electricity price	−20%	+20%
Investment cost	+20%	−20%
Emission factor	−20%	+20%
Value of CERs	10 €/t CO_2eq	25 €/t CO_2eq

Contrary to these parameters, the other two factors, which are related with the implementation of the CDM, seem to have a rather limited impact on the profitability of the wind power projects. Under the most optimistic circumstances, the observed absolute increase in the IRR does not exceed 0.8% for a 20% increase of the emission factor and approximately 2.5% for an increase of 10 €/t CO_2eq in the CERs value. Fig. 10 summarizes in percentage units the proportional average impact of increases in the values of the examined parameters on the IRR in all examined countries.

This finding confirms that the CDM does not play a decisive role in making wind energy projects sufficiently attractive neither gives a substantial impetus encouraging investors to undertake the risk of making business in developing countries. The support provided by the classical instruments of subsidizing investment cost and/or securing favorable electricity tariffs for RES, is by far more significant. Of course, the selection of the

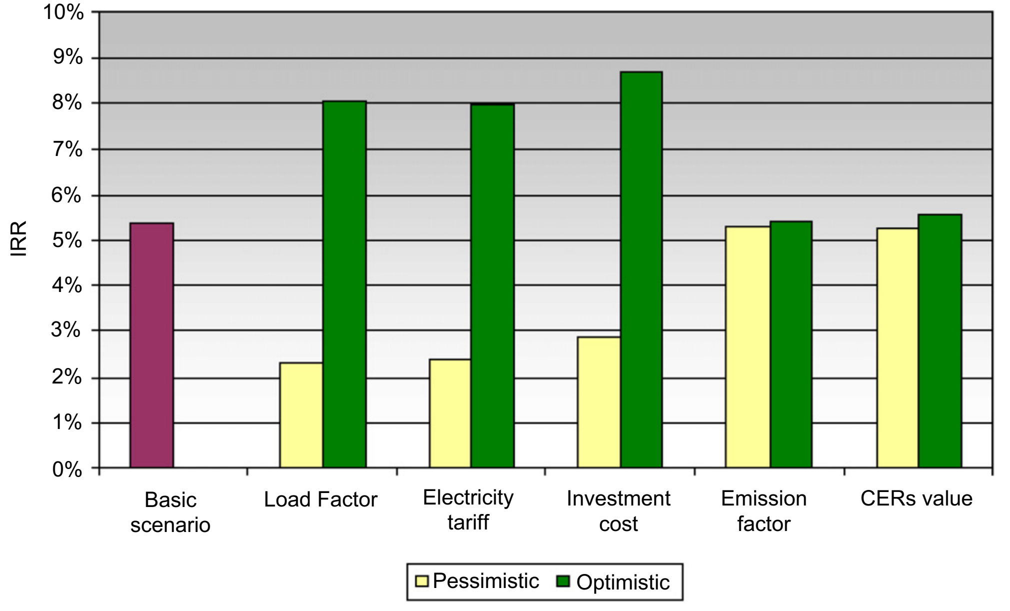

Fig. 7. Sensitivity analysis of the profitability of a wind energy project in Armenia.

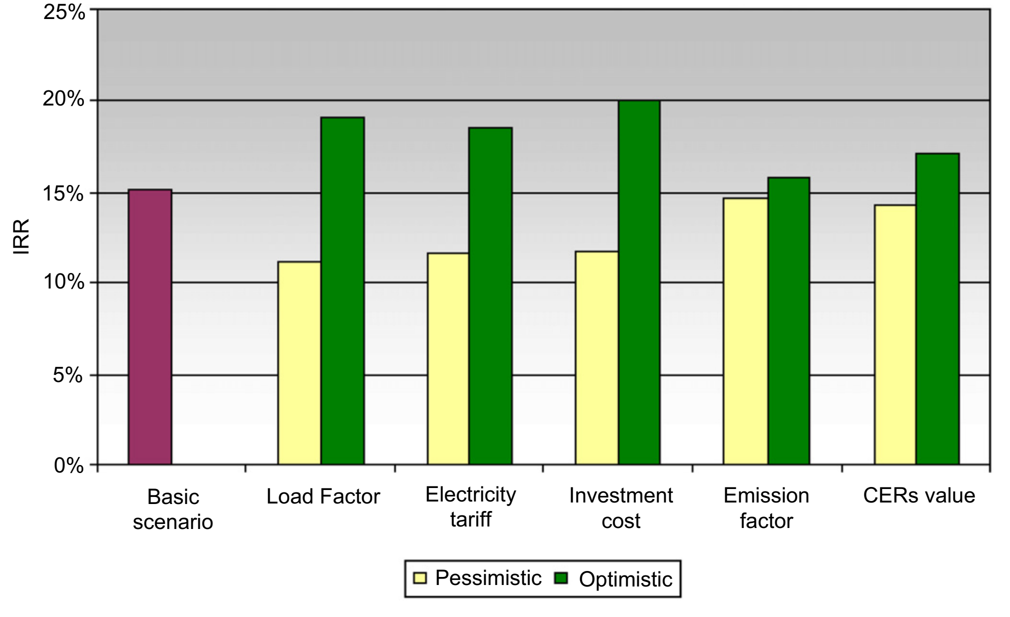

Fig. 8. Sensitivity analysis of the profitability of a wind energy project in Jordan.

particular location of the wind farm installation is also of crucial importance since small variations in the load factor appear to have a considerable effect on the profitability of the investment.

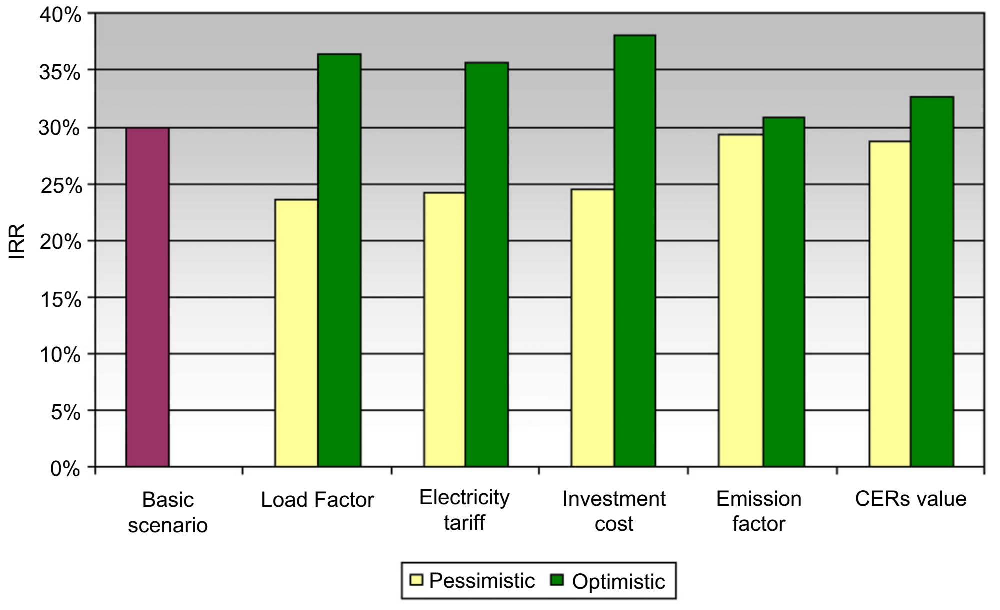

Fig. 9. Sensitivity analysis of the profitability of a wind energy project in Morocco.

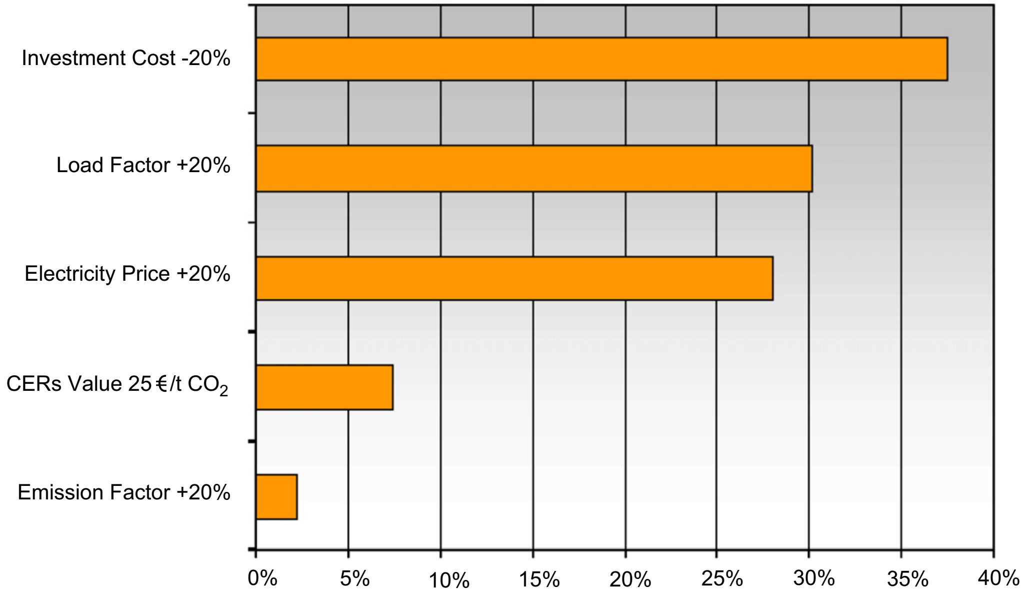

Fig. 10. Average impact of favorable changes in the values of parameters on the IRR of wind energy projects.

4.5. MCDA

Economic return is not the only factor guiding investment decisions. The overall business environment is also a critical factor, although being a rather ambiguous concept.

There are different aspects in the political, administrative and legal conditions that contribute to the security feeling of potential investors about the ease of making business in a country. For this reason, international bodies provide relevant information to investors by rating in cardinal scales all countries, with respect to different factors influencing the general entrepreneurial climate. In the present analysis, the following measurable criteria are considered by using the ratings of the World Bank [43,44]:

- Political stability
- Control of corruption
- Ease of doing business

In addition, the legal framework in each country and particularly the existing provisions or omissions of the host country regarding the development of RES are also taken into consideration as significantly influencing the unimpeded realization of the project. This factor (legal status) is rated on a 3-level qualitative scale on the basis of information included in the countries' national reports to the UNFCCC and/or in other official documents [13,20,40,45–50], where:

(1) denotes absence of legislative framework or of any reference to future provisions;
(2) denotes insufficient legislative structure with only fragmentary and/or deficient provisions;
(3) denotes existence of sufficient legislative framework.

The performance of the five qualified countries in each evaluation criterion and the desired optimal values (max or min) are presented in Table 5. Table 6 specifies the indifference and preference thresholds used in the ELECTRE III method in order to take into account uncertainties in the performances and ambiguities in human preferences and accordingly relax the comparison between pairs of countries.

The relative importance of the so defined criteria is assumed to vary according to the weighting scenarios presented in Table 7. The rationale behind these scenarios lies on the distinction between economic return and business environment, with the four components of the latter considered to be of equal importance. Namely, economic return is assigned with weights from 70% to 40%, with the sum of weights of the other four criteria changing from 30% to 60%, respectively.

Table 5
Evaluation matrix for the multicriteria analysis of qualified countries

Country	IRR	Political stability [43]	Control of corruption [43]	Ease of doing business [44]	Legal status
	Criterion direction				
	Max (%)	Max	Max	Min	Max
Albania	10.47	−0.97	−0.72	117	1 [13]
Armenia	5.35	−0.51	−0.53	46	2 [13]
Jordan	15.21	−0.12	0.35	74	2 [40,45,46]
Morocco	30.04	−0.23	−0.02	102	2 [49,50]
Tunisia	21.43	0.16	0.29	58	3 [20,47,48]

Table 6
Criteria thresholds used in ELECTRE III

Coefficient	IRR	Political stability	Control of corruption	Ease of doing business	Legal status
Indifference threshold					
a	0.1	0.1	0.1	0.1	0
b	1	0.1	0.1	10	0
Preference threshold					
a	0.1	0.1	0.1	0.2	0
b	2	0.2	0.2	20	0

Table 7
Weighting scenarios

Scenarios	IRR	Political stability	Control of corruption	Ease of doing business	Legal status
A	0.7	0.075	0.075	0.075	0.075
B	0.6	0.1	0.1	0.1	0.1
C	0.5	0.125	0.125	0.125	0.125
D	0.4	0.15	0.15	0.15	0.15

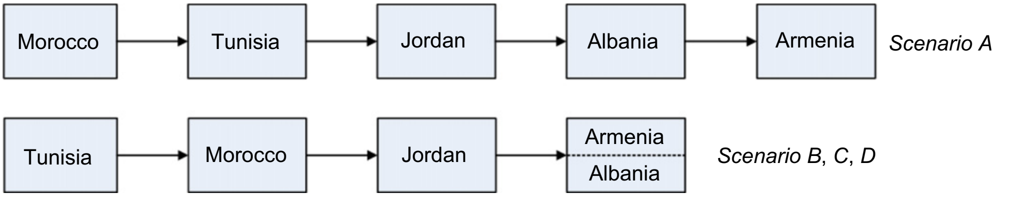

Fig. 11. Multicriteria ranking of countries for the different weighting scenarios.

As shown in Fig. 11, the multicriteria ranking of countries does not significantly vary in the examined weighting scenarios. It is namely shown that Morocco and Tunisia are the most attractive among the examined countries to host a wind energy project, since their high IRR values go along with satisfactory performances in most of the other four criteria. On the opposite side Albania and Armenia share the last places of the obtained order because their low rates of return are not counterbalanced from a favorable business environment. Thus, the obtained results are almost identical with the ranking provided by IRR, with the most notable difference being the order reversal between Morocco and Tunisia, if the relative importance assigned to the economic criterion is equal or less than 60%.

5. Conclusions

This paper presents a stepwise evaluation procedure for screening a number of candidate developing countries in order to come up with one or two countries appearing as the most

attractive locations to host a project on wind energy exploitation in accordance with the rules of the clean development mechanism (CDM) of the Kyoto Protocol (KP). In addition to the above key objective, the analysis aims at determining the support provided by the CDM and investigating the impact of the key parameters influencing the profitability of a wind energy project. The analysis is restricted to 15 countries in Eastern Europe, Northern Africa and Middle East representing relatively virgin but growing CDM markets.

The results of the financial analysis show that only few of the examined countries fulfill the necessary conditions for being considered as potential host countries for wind energy projects. Even if the wind energy potential is sufficiently high, the overall economic return might be low mainly because of low electricity tariffs. It is also revealed that the CDM is not effective enough to transform a project with low economic return into an appealing investment opportunity. Instead, it should be seen as an instrument to minimize the risk of relevant investments in already attractive locations. More specifically, the factors related with CDM revenues, namely the baseline emission factor and the price of CERs in the carbon market have a very small impact on the project's profitability. The performed sensitivity analysis shows that investment cost and electricity tariffs are the decisive parameters influencing economic return, together with the load factor of the specific site. This means that a rapid deployment of wind energy in the developing world necessitates the implementation of policy measures such as subsidizing investment cost and/or establishing green tariffs that are adopted in most developed countries presenting high advancement in wind energy capacity.

The selection of the most promising host country results by widening the evaluation perspective as to include additional criteria regarding the ease of making business in the examined countries. It comes out that by taking into account political, administrative and legal aspects, a potential investor might prefer to undertake the business in a country presenting a lower economic return but a more favorable and less risky business environment.

The proposed evaluation approach is appropriate as a decision-aiding procedure to guide investment activities in innovative technologies that are highly sensitive to country-specific technical, financial or political parameters. Moreover, it can be easily accommodated for investigating any type of clean technology in any set of candidate host countries as defined by either the CDM or the Joint Implementation mechanism of the KP.

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